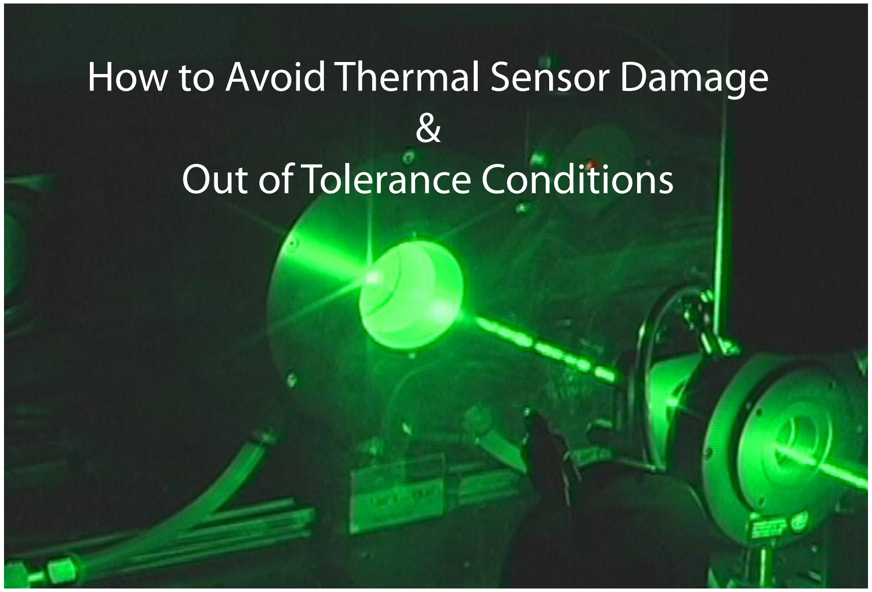


Overview

We believe that Ophir thermal sensors can be used for many years without the need of repairs when used with the proper laser optical setup. We hope that this document will enable you to enjoy the long life and reliable results for which Ophir-Spiricon is known.

This document was created to assist our valued customers in the proper care and maintenance of Ophir thermal laser power sensors. The following information is for reference only. If you have any reason to believe that the sensor is no longer performing within the original specifications, we always recommend that you send it in for repair and/or recalibration by our trained technicians to bring the unit back within the proper NIST traceable standards.

Some Common Reasons for Out of Tolerance Conditions:

Outlined in this document are the three most common reasons for an out of tolerance data report. This is not a complete list of reasons for a thermopile sensor to fall out of tolerance. If replaced, typically the old used absorber is sent back with your sensor after recalibration. Please take a moment to look over your old absorber and compare it to the examples outlined below.

I) Surface Contamination

Explanation: Many times an out of tolerance condition can be explained simply by surface contamination induced by environmental conditions. Unfortunately, due to the different environments that sensors are used in, it is nearly impossible to conclude exactly what causes the contamination in each scenario. Welding environments are a common source of contamination; however any environment may allow foreign material to be deposited on the sensor if care is not taken. Grease from fingerprints is another common source of contamination and it can be burnt into the surface of the absorber. The use of a form of combustible material to determine beam location prior to sensor use can also contaminate your sensor. Burn paper or any other combustible material used near the sensor can slowly deposit contaminants onto the surface. Unfortunately the contamination can be gradual and uniform in distribution, preventing the end user from noticing a change in the shade of the coating Please refer to Figures 1 and 2.

Examples:

Fig. 1 Gradual Contamination on the left, after cleaning on the right. The type of contamination on this disc is undetermined, but notice how uniform the foreign material is deposited. Only a trained technician can quickly identify this type of contamination. A simple way to test for this is to compare the color of the coating between many different sensors of the same model or coating type. If there is a large deviation in shade, one of the discs might be contaminated.

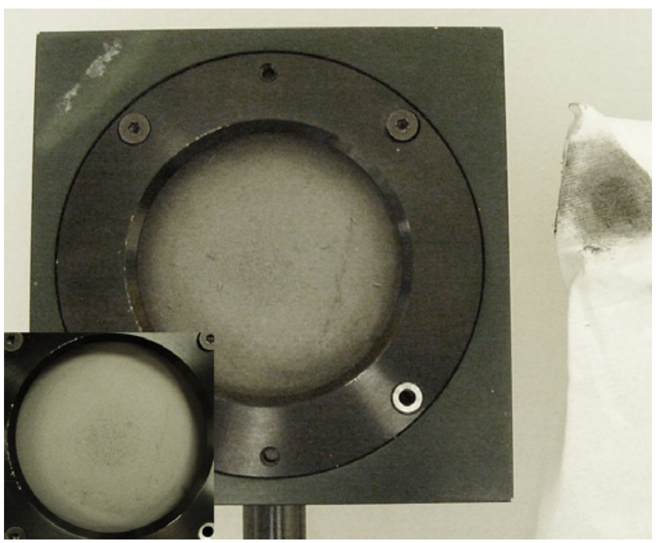


Fig. 2 Here you will find an example of welding contamination. Centered is the disc after one swipe with the cleaning cloth. Note the level of contamination on the cloth. In the lower left corner is the same disc after the cleaning process is complete.

Corrective Action:

The first step is to determine the source of the foreign contami nants. Then steps should be taken to isolate the sensor from future contamination. Storing the sensor in the proper container when not in use is sometimes all that is necessary to prevent long term contamination. Also a brief blast of compressed dry air prior to applying laser power goes a long way in preventing the build up of foreign material. We do not recommend any cleaning to be done except by our trained technicians when the sensor is sent for repair/recalibration as any change to the absorber surface will cause a deviation in readings. Please also refer to the overheating section below, as overheating may be a source of contamination.

II) Overheating of the sensor housing

Explanation: This occurs when the disc is used continuously at a power level higher than it is rated for. Many of our sensors are rated at one specific power level for continuous laser power and a separate higher level for shorter periods of use. Numerous sensors have names ending in the letter "C". These sensors are designed specifically to be installed into a heat sinking system for convection cooling. When not installed with a heatsink, the maximum power level is reduced significantly. One example of this is the 20C-SH sensor, which is capable of handling 20 watts when used with a heatsink, but only 4 watts freestanding. Please refer to the specification sheet originally provided with your sensor when new if you believe it may need heatsinking.

Two types of damage can occur from overheating of the sensor housing. The first is coating failure. This is fairly common and will result in a large discoloration of the coating surface. This discoloration is not removable by cleaning. In this situation the absorber must be replaced due to inconsistent absorption across the surface. Refer to Figures 3 and 4.

Examples:

Fig. 3 This is a typical example of coating failure as a result of overheating. The picture was taken after cleaning. Notice that the entire disc is darker than previous cleaned examples. This disc must be replaced.

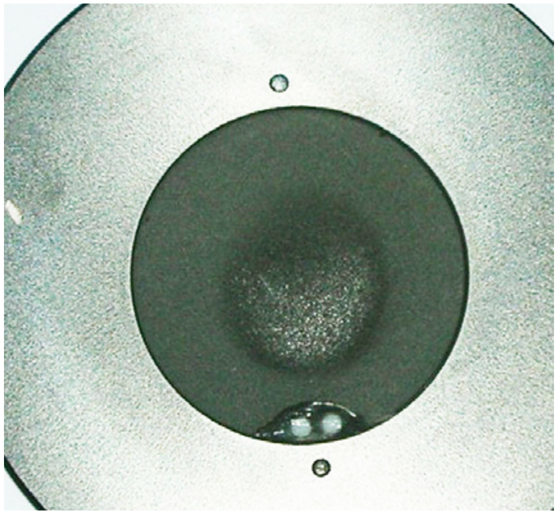
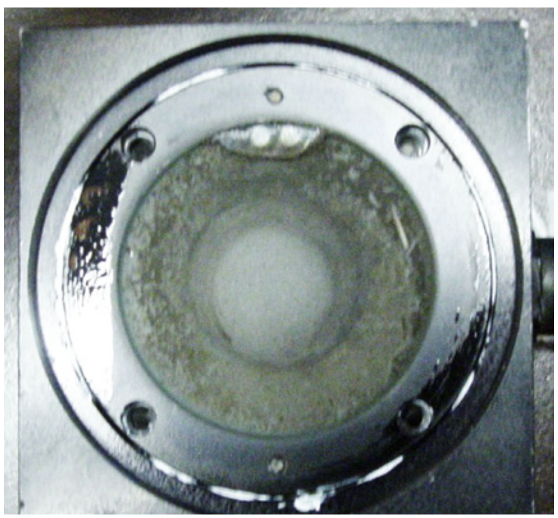


Fig. 4 This is a great example of a combination of the two types of damage resulting from overheating as described above. Notice that the central region has a large ring of damage. Also notice that the grease has begun to fail and is starting to migrate onto the surface of the absorber. This disc must be replaced.



The second type of damage is grease contamination. When the disc is overheated, the thermal coupling grease between the sensor and its housing will begin to deteriorate. This can, and often does, result in a ring of grease contamination that slowly migrates onto the surface of the absorber. Grease contamination typically does not affect the readings in the far infrared region; however near infrared and shorter wavelengths will read greater than actual once contaminated. In most cases, disassembly, regreasing, and cleaning of the absorber by our technicians can remedy this issue without the need for costly disc replacement. Any time the grease of a sensor is disturbed, the single shot energy as well as the response time are typically no longer within specification. Please refer to Figures 4 and 5.

Fig. 5 Pictured here is an example of grease contamination from overheating only. Notice that it has not quite made it to the center of the absorber. This disc could likely be cleaned and put back into service, although that is not always the case.

Corrective Action: To prevent overheating, please refer to the limitations of the sensor as outlined in the specification sheet originally sent with the sensor when new. A proper heatsink as well as taking care not to exceed the temperature limit of the disc will prevent this type of damage from occurring.

III) Localized overheating of the coating

Explanation: This is the number one cause of disc replacement with our sensors. Each coating type offered by Ophir-Spiricon has a specific power and energy damage threshold for localized power and energy shots incident on the surface of the absorber. The specification sheet for each sensor will specify the general limit for power and energy damage. The following formulas are used to determine the power and energy density of your laser beam respectively:

For CW lasers:

[formula 1]

Power Density = [power (W) / (0.785 * diameter^2)]

[formula 2]

Power Density = [(energy per pulse (J) * rep. Rate (Hz)) / (0.785 * diameter^2)]

For pulsed lasers:

[formula 3]

Energy Density = [(energy per pulse (J)) / (0.785 * diameter^2)]

These formulas have a few assumptions that may not always be the case. The first assumption is that the laser beam profile is a homogenous one i.e. flat top profile. This is not the case for all lasers. Many lasers have a Gaussian profile, while others have spikes or other abnormalities in the profile. These spikes can often have many factors of power and energy density greater than the beam has on average, resulting in small burn marks and localized overheating of the coating. Ophir-Spiricon has a wide range of beam profiling devices available if you would like to determine the profile of your laser.

Another subtle but extremely important thing to keep in mind is that pulsed lasers, particularly those with short pulse lengths (< ~500 us) have extremely high instantaneous energy densities. For example, although the laser might be pulsing at 5 Hz, if the pulse length is only 10 ns, all of the power is being delivered in an extremely short time. For a 10 watt average power pulsed laser at 5 Hz with a 10 ns pulse length, this would imply that the instantaneous energy density during each pulse is:

(2 watts / 10 ns) = 2*108 W/s = 200,000 kW/s

This is a theoretical example, and demonstrates the extreme damage capabilities of pulsed lasers. Many users occasionally get away with this type of use as the sensor is exposed to the instantaneous energy density for such a short period of time that the coating is literally being disintegrated in microscopic layers at a time. Due to the subtle nature of this type of damage, many times the user will not notice it occurring until after a significant number of pulses. This form of damage results in the largest number of sensor replacements. Please refer to Figures 6 through 13.

Examples:

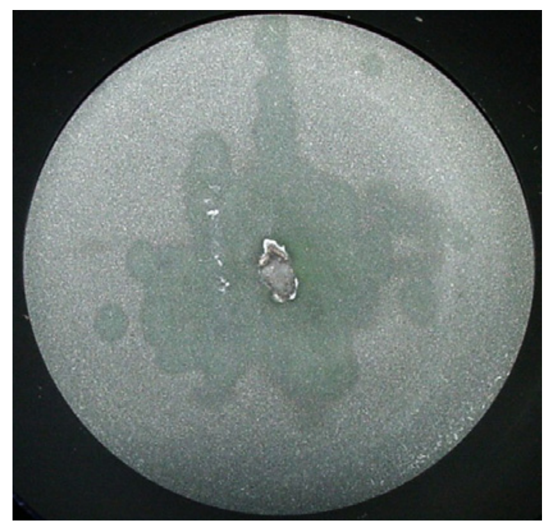


Fig. 6 This is the traditional look of excessive continuous power density. Notice that the coating has completely failed at the center of the disc. Increasing beam diameter is typically the only solution in this situation.

Fig.7 Another example of excessive power density. This was a high power water cooled disc. The spot size must be increased to prevent this type of damage.

Fig.8 Another example. This disc appears to have not only had the local power density exceeded in the center, but also the entire disc looks to have been overheated, resulting in the grease contamination that is visible on the upper right edge.

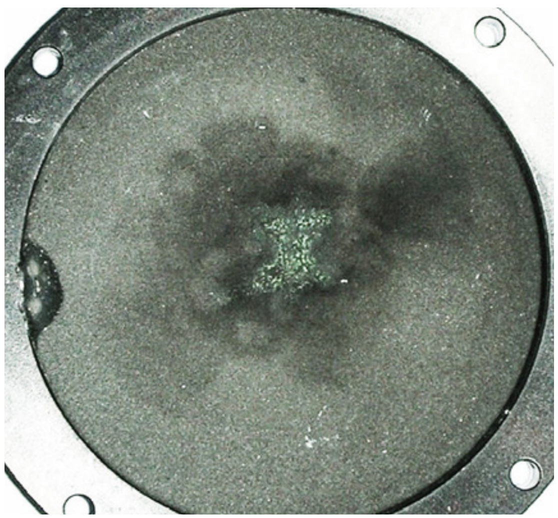


Fig. 9 This type of damage is typical of a bad laser profile. The laser was likely outputting a profile with a major peak, resulting in the small burn in the center.

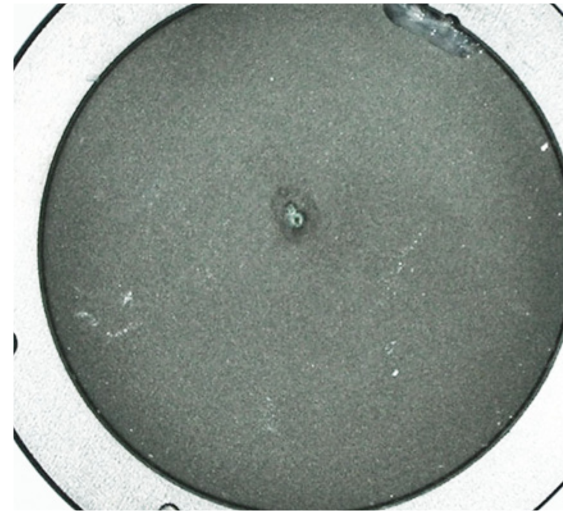
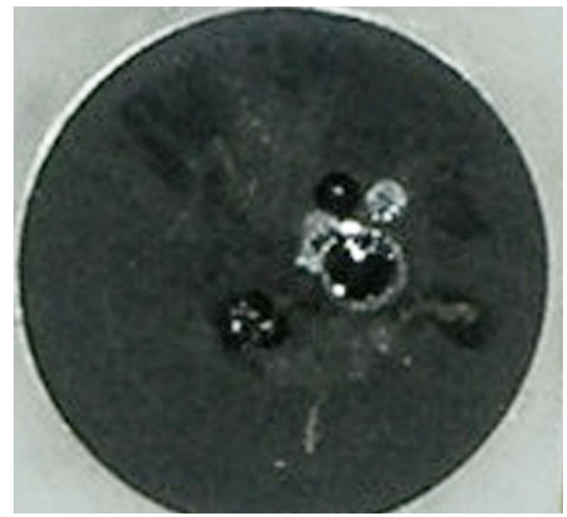


Fig. 10 This is an example of excessive power density on one of our P-type absorbers. The P-type discs actually melt when the damage threshold is exceeded. Many times smaller melted spots (<~0.5mm diameter) will still read within specification and may not require replacement.



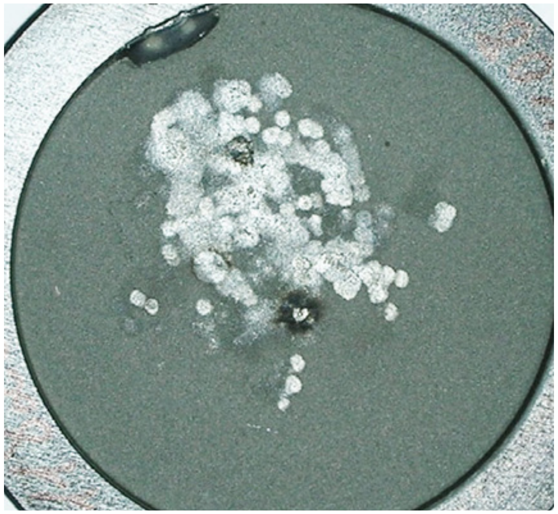


Fig. 11 This is classic damage caused by excessive energy density. Notice that the coating is being damaged one layer at a time. The users in this case likely noticed a change in the readings on the meter, and therefore moved the position of the beam around to new areas as they used it.

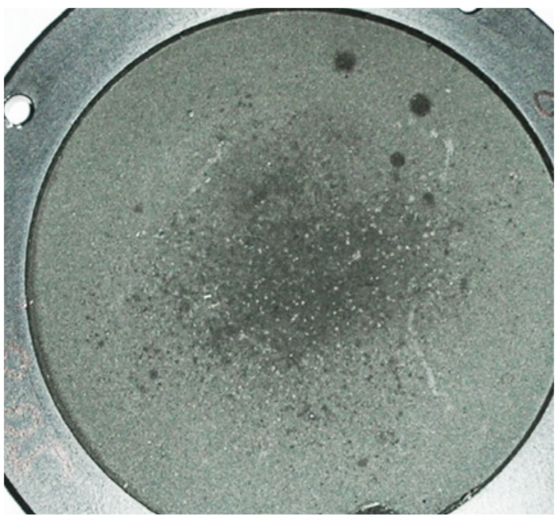


Fig. 12 This is another example of pulsed energy density damage. Notice how the coating is slowly deteriorating. This is likely a very short pulse laser. This will typically result in a higher reading than actual.

Fig. 13 This is the same damage as shown in Fig. 12, simply after significantly more pulses. Notice that the coating is now completely gone in the center. Once the coating turns shiny or white, the reading is typically lower than actual.

Corrective Action: To prevent localized overheating of the coating, the simplest solution is to expand the laser beam to a size that will greatly reduce the power and energy density. 1/3 of the aperture diameter is usually a good size, although larger can be used if necessary to prevent damage. This will prevent nearly all problems related to average power density. If the beam is already as large as possible, please contact one of our customer service representatives and we will help find a solution for your specific situation. We have many different coatings designed to hold up to specific laser systems better than others. For pulsed lasers we have what are called volume absorbers that absorb the energy pulses in a manner that distributes the heat through a surface. This results in significantly higher energy density limits if you are having damage due to pulsed laser systems.

The following example is useful to illustrate the importance of beam size:

Laser Power: 100W

Beam Size: 2.0mm

Power Density = [power (W) / (0.785 * diameter^2)]

Power Density = [100W / (0.785 * 0.2cm2)] = 3.184 kW/cm2

However if one was to simply expand the beam to 10mm or 1.0cm

Power Density = [100W / (0.785 * 1.0cm^2)] = 0.127 kW/cm^2

(0.127 kW / 3.184 kW)*100 = 3.99%

As illustrated in the example above, simply expanding the beam from 2.0mm to 10.0mm resulted in decrease in total power density by over 96%! If your laser is divergent, expanding the beam is as simple as moving the sensor further away from the focal point. If you have a laser with low divergence, commercially available beam expanders or simple negative lens systems may be the best option. Please consult with the proper personnel before attempting to change any laser optical system, as improper setup can result in serious injury.

Need Additional Help?

Here at Ophir-Spiricon we are committed to the satisfaction of our customers. If you would like to speak to a representative about any information contained in this article, about new products, or to optimize your laser measurement system for accurate, consistent, and highly repeatable results, please do not hesitate to contact us. See contact information on back.

Ophir Power and Energy Meters – Versatility for Every Application

Ophir sensor, power meter and computer interface system means that virtually any sensor can work "plug and play" with any power meter or computer interface. Ophir has the widest range of sensors on the market with the highest performance so almost any measurement need can be accommodated. The measurement results can also be used in many ways - on the power meter screen, stored on board, sent to PC with results presented in many ways and on several platforms.

About Ophir-Spiricon

With over 30 years of experience, the Ophir Photonics Group provides a complete line of instrumentation including power and energy meters, beam profilers, spectrum analyzers, and goniometric radiometers. Dedicated to continuous innovation in laser measurement, the company holds a number of patents, including Ophir-Spiricon's Ultracal™, the baseline correction algorithm that helped establish the ISO 11146-3 standard for beam measurement accuracy. The recently acquired Photon family of products includes NanoScan scanning-slit technology, which is capable of measuring beam size and position to sub-micron resolution. The company's modular, customizable solutions serve manufacturing, medical, military, and research industries throughout the world.

OPHIR Photonics Group

Spiricon Photon

Ophir-Spiricon Calibration Team

3050 North 300 West

North Logan, UT 84341

435-753-3729

calibration@us.ophiropt.com

www.ophiropt.com/photonics